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Original Contributions

HEART DISEASE MORTALITY IN NONSMOKERS LIVING WITH SMOKERS

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A private census of Washington County, Maryland, in 1963 obtained information on smoking habits of all adults in the census, and death certificates of all residents who died in the next 12 years were coded for underlying cause of death and matched to the census. Among the white population aged 25 and over, 4,162 men and 14,873 women had never smoked. In this group, death rates from arteriosclerotic heart disease were significantly higher among men (relative risk (RR) = 1.31, 95% confidence interval (CI) 1.1–1.6) and women (RR = 1.24, 95% CI 1.1–1.4) who lived with smokers in 1963, after adjustment for age, marital status, years of schooling, and quality of housing. Among women, the relative risk increased significantly ($p < 0.005$) with increasing level of exposure; among men, there was little evidence of a dose-response relation. The relative risks for nonsmokers who lived with smokers were greatest among both men and women who were younger than age 45 in 1963, but the number of deaths in these groups was small, and confidence intervals were broad. These results suggest a small but measurable risk for arteriosclerotic heart disease among nonsmokers who live with smokers.

heart diseases; smoking; tobacco smoke pollution

The association of cigarette smoking with arteriosclerotic heart disease deaths is well-known (1), and it is now increasingly suspected that the presence of smoke in the environment may pose a risk to nonsmokers. Evidence on the possible association of what is called passive smoking with arteriosclerotic heart disease is as yet far from conclusive, and both the Surgeon General's recent report (2) and that of the National Research Council of the National Academy of Sciences (3) emphasize the need for additional studies. As pointed out by the Surgeon General, because heart disease is so prevalent, even a small increase in risk associated with passive smoking could have a substantial public health impact.

Some epidemiologic studies have been conducted concerning the possible association of arteriosclerotic heart disease with passive smoking. A recent case-control study by Lee et al. (4) reported no consistent evidence of greater passive smoke ex-

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posure among 118 hospitalized nonsmoking cases than among nonsmoking controls hospitalized for reasons considered unrelated to smoking. Gillis et al. (5) reported results of up to 10 years of follow-up for 8,128 Scottish adults aged 45–64 years who participated in a multiphasic health screening exam and for whom smoking history of a spouse or partner was known. At the initial examination, nonsmoking women who lived with smokers had slightly more cardiovascular symptoms such as angina or abnormal electrocardiogram than nonsmokers who were not exposed. No such excess was reported for men. At follow-up, death rates from myocardial infarction for nonsmoking men and women married to smokers were midway between rates for nonexposed and those for active smokers. The number of observed deaths was small, and differences were not statistically significant. Garland et al. (6, 7) reported a dose-response relation in women aged 50–79 years between the amount their husbands smoked and death rates from ischemic heart disease, but the number of deaths was small, and the differences were less than statistically significant, despite a relative risk of 2.7. Hirayama (8) reported in his 15-year prospective study that there was a significantly higher risk of ischemic heart disease among Japanese women whose husbands smoked as compared with those whose husbands did not smoke, as well as a significant dose-response relation with amount smoked. Svendsen et al. (9), in the Multiple Risk Factor Intervention Trial prospective study, found that nonsmoking men whose wives smoked had roughly twice the risk of coronary heart disease morbidity and mortality compared with those whose wives did not smoke. Of particular interest is their finding of no difference between the two groups in blood pressure or cholesterol levels.

Data from a private census conducted in 1963 and other records available in Washington County, Maryland, were used to evaluate the heart disease risk associated with household smoke exposure among nonsmoking adults. The results of this 12-year follow-up study are reported here.

Materials and Methods

In July 1963, a private census obtained data on an estimated 98 per cent of the households in Washington County, Maryland. Information included sex, age, race, marital status, years of schooling, and housing characteristics for all 91,909 individuals enumerated. Information on cigarette, cigar, and pipe smoking habits as well as frequency of church attendance was recorded for each household member aged 16½ or older as of July 15, 1963. A follow-up of a 5 per cent sample of the households in the 1963 census was conducted in 1971 in order to assess the probability of still living in Washington County after eight years. Since age, marital status, years of schooling, and frequency of church attendance were the only characteristics that showed significant association with remaining in the county, a probability of remaining in the county was calculated for each adult in the census aged 25 and over based on those factors and was entered on the census tape. These probabilities allow the population remaining in the county to be estimated at any point in the eight-year period. Since only about 2 per cent of the noninstitutionalized 1963 population was black, the present study is confined to whites.

All death certificates of Washington County residents who died between July 1963 and July 1975 have been coded as to primary, contributing, and underlying causes of death without knowledge of census data, and the information was entered on the census tape for decedents who were in the 1963 census. The Seventh Revision of the *International Classification of Diseases* (ICD) (10) was used for coding causes of death; for this study, we used only deaths with underlying causes of death classified as arteriosclerotic heart disease including coronary disease (ICD 420) and other myocardial degeneration (ICD 422). We also analyzed deaths for which arteriosclerotic

heart disease was listed on the death certificate but not coded as the underlying cause of death to confirm that similar associations were observed. The category other myocardial degeneration was included because many physicians in this community refer to deaths due to coronary artery disease as arteriosclerotic cardiovascular disease, which is classified under ICD 422.

For the current study, all adults were assigned smoking contribution scores (table 1) ranging from 0 to 12 based on their reported smoking histories—never smoked, present or ex-smoker of cigarettes, cigars, or pipe, and amount smoked. In general, current smokers were assigned scores that were twice those of ex-smokers of like amount. The only exception to this was for persons who only smoked a pipe and/or cigars; census data did not distinguish between current or past pipe or cigar smokers. When pipe and/or cigar smokers also currently smoked cigarettes, however, they were assumed to be current pipe and/or cigar smokers. The contribution to household exposure of only pipe and/or cigar smoke was treated as less than that of current smokers of fewer than 10 cigarettes. Although the household exposure from a pipe or cigar may equal or exceed that from a cigarette, it was arbitrarily assumed that cigar or pipe smokers who never smoked cigarettes would, in general, smoke fewer pipes or cigars per day than light cigarette smokers. Only 9 per cent of spouses of nonsmoking females smoked only pipes and/or cigars. Thus, the impact of this arbitrary ranking of pipe and cigar smokers and current light smokers is not likely to be large. A household exposure score was calculated as the sum of the contributions of all persons living in that household, and each person's passive smoke exposure score is the household score minus his or her own contribution to it.

TABLE 1

Calculation of each person's contribution to smoke exposure in the home

Smoking status	Ex-smoker	Current smoker
Never smoked	0	0
Cigars and/or pipe only*	1	1
Cigarettes		
<10/day	1	2
10–20/day	3	6
21+/day	5	10
If cigars and/or pipe in addition to cigarettes, add	1	2

* Census data did not distinguish between ex- and current pipe or cigar smokers.

A housing index (ranging from 0 to 10) based on running water, number of bathrooms, type of heating system, cooking fuel, and availability of telephone is a rough indicator of quality of housing. In the absence of solid data on household income, the housing index acts as a surrogate measure, particularly to identify the very low-income households.

Among the 22,973 white men and 25,369 white women aged 25 and over in the 1963 census, 4,162 men and 14,873 women reported that they had never smoked. The calculated 1969 midpoint remaining population of these nonsmokers, based on the 1971 follow-up, was 3,454 men and 12,345 women; these constitute the population of interest for this study.

Death rates were calculated as deaths in 12 years per 1,000 midpoint population, adjusted for age, housing quality, marital status, and years of schooling by the binary variable multiple regression procedure described by Feldstein (11) and adapted for epidemiologic use by Shah and Abbey (12).

RESULTS

Table 2 shows the characteristics of the Washington County white population aged 25 and older originally listed in the 1963 census and the percentage in each category reporting that they had never smoked. As was characteristic of that period, relatively few men but more than half the women had never smoked. Among men, there was a slight tendency for the better educated to have a higher percentage of nonsmokers, a trend opposite to that among women.

Characteristics of the population of interest for this study, those who never

TABLE 2

Percentage of original census population who reported they had never smoked, by demographic characteristics, whites aged ≥25 years, Washington County, MD, 1963

Characteristic	Men		Women	
	No.	% never smoked	No.	% never smoked
Total	22,973	18.1	25,369	58.6
Age (years)				
25–44	10,928	16.5	11,652	46.7
45–54	5,104	16.1	5,378	53.3
55–64	3,631	17.2	4,001	70.1
65+	3,310	27.6	4,338	86.6
Marital status				
Married	19,699	17.4	18,704	55.4
Other	3,274	22.4	6,665	67.6
Grades of school completed				
0–8*	9,977	19.1	9,929	68.5
9–11	4,527	13.1	5,497	52.4
12	5,256	19.1	6,802	54.4
13+	3,213	20.4	3,141	47.6
Housing index				
0–7	4,591	15.9	4,512	59.9
8–10	18,382	18.7	20,857	58.4

* Includes participants for whom grades of school completed was not known.

smoked, are listed in table 3, which shows the calculated midpoint populations in 1969 and the percentage of each group exposed to tobacco smoked by others in the household. For both men and women, the percentage exposed to environmental smoke in the home tends to drop with increasing age and with higher quality of housing. There is, however, a sex difference in the association of education with percentage exposed, nonsmoking men showing slightly increased exposure with more years of schooling and nonsmoking women showing a slight trend in the opposite direction. In addition, married men are less likely and married women more likely to be exposed to the smoke of others in the home.

Table 4 shows the adjusted rates of death from arteriosclerotic heart disease (ICD 420 and 422) in the 12-year period 1963–1975 among men and women who never smoked, according to their level of passive smoke exposure at home. The overall rates are adjusted for age, quality of housing, marital status, and years of schooling. For men, the relative risk for those with some household exposure compared with the nonexposed is statistically significant (relative risk (RR) = 1.31, 95 per cent confidence interval (CI) 1.1–1.6), but the trend with increasing exposure is negligible. For women, both the difference between the exposed and nonexposed (RR = 1.24, 95 per cent CI 1.1–1.4) and the trend of increasing mortality with increasing levels of exposure in the home (Cochran chi-square = 9.2, $p < 0.005$) are statistically significant. The balance of table 4 presents the adjusted arteriosclerotic heart disease mortality rates for each age group by level of smoke exposure at home. The age group 25–44 years shows the highest relative risks for both men and women, but because of the very small numbers, the 95 per cent confidence limits are quite broad. Nevertheless, it is worthy of note that seven of the eight age-sex groups show increased risk of arteriosclerotic heart disease deaths with passive smoke exposure in the home, and five of the eight indicate a trend with increasing level of exposure.

Results have been shown only for heart disease deaths that were classified as underlying cause of death. Although not

TABLE 3

Distribution of midpoint population of whites aged ≥25 years who never smoked, by sex, percentage exposed to smoke at home, and demographic characteristics, Washington County, MD, 1963–1975

Characteristic	Men		Women	
	No.	% exposed in the home	No.	% exposed in the home
Total	3,454	29.5	12,345	65.5
Age (years) in 1963				
25–44	1,502	30.0	4,618	72.0
45–54	731	34.3	2,553	72.1
55–64	554	28.2	2,472	62.8
65+	667	24.4	2,702	50.5
Marital status				
Married	2,929	27.2	9,033	75.7
Other	525	42.7	3,312	37.5
Grades of school completed				
0–8*	1,578	27.0	5,589	62.7
9–11	504	29.4	2,455	70.0
12	862	31.7	3,158	68.6
13+	510	34.1	1,143	60.6
Housing index				
0–7	594	33.7	2,238	68.2
8–10	2,860	28.7	10,107	64.9

* Includes participants for whom grades of school completed was not known.

shown, death rates and relative risks were also calculated for heart disease deaths coded as a primary cause or a contributing cause of death. A total of 461 nonsmoking men and 1,281 nonsmoking women had arteriosclerotic heart disease listed on the death certificate. Of these, 80 per cent of men and 77 per cent of women were considered to have heart disease as the underlying cause of death. Results were similar whether or not heart disease was considered by the nosologist to be the underlying cause of death. For example, the adjusted relative risk among exposed nonsmoking women compared with nonexposed women was 1.2 for heart disease listed anywhere on the death certificate and 1.1 when heart disease was on the death certificate but not considered to be the underlying cause of death. For males, the corresponding relative risks were 1.3 and 1.4.

DISCUSSION

The findings of this study tend to confirm those of Hirayama (8), whose relative risk from ischemic heart disease was 1.3 for nonsmoking women married to smokers; our relative risks, however, are considerably lower than those of Garland et al. (7) and Svendsen et al. (9) and higher than those of Lee et al. (4).

There are a number of strengths in this study. Information on smoking was collected for each person in 1963, and follow-up procedures were the same for everyone. Some potential biases were thus avoided: those involved in asking people (or their family members) about prior smoking habits after an illness or death, when recall may be colored by an unconscious search for any possible cause of the illness, and those involved in selecting controls from hospital populations. Furthermore, smoking histories were recorded prior to publication in 1964 of the Surgeon General's first report on smoking and health (13) and the subsequent increase in concern about smoking.

Obviously, the home is not the only place where nonsmokers may be exposed to tobacco smoke. Any association of household passive smoke exposure with heart disease mortality may, in this study, appear weaker than the actual association to the extent

TABLE 4

Deaths from arteriosclerotic heart disease among nonsmokers exposed or not exposed to tobacco smoke in the home, adjusted rates per 1,000 population, relative risks, and 95 per cent confidence intervals, Washington County, MD, 1963–1975*

Age (years) in 1963	Passive smoking score	Men					Women				
		Midpoint no.	Deaths	Adjusted rate	Relative risk	95% confidence interval	Midpoint no.	Deaths	Adjusted rate	Relative risk	95% confidence interval
All ages	0	2,434	248	98.1	1.00		4,259	437	69.2	1.00	
	1+	1,020	122	128.5	1.31	1.1–1.6	6,066	551	85.8	1.24	1.1–1.4
	1–5	459	56	135.9	1.38	1.1–1.8	3,412	252	83.0	1.20	1.0–1.4
	6+	561	66	122.5	1.25	1.0–1.6	4,674	299	87.8	1.27	1.1–1.5
25–44	0	1,052	4	3.2	1.00		1,291	1	1.1	1.00	
	1–5	211	1	5.7	1.76	0.3–10.6	1,286	3	2.4	2.18	0.4–12.6
	6+	239	4	18.4	5.70	1.6–21.4	2,041	8	3.7	3.35	0.7–16.2
45–54	0	480	30	62.0	1.00		713	8	8.9	1.00	
	1–5	109	8	75.4	1.22	0.6–2.5	701	8	13.2	1.48	0.6–3.9
	6+	142	10	70.6	1.14	0.6–2.2	1,139	16	14.4	1.62	0.7–3.9
55–64	0	396	51	129.2	1.00		919	75	79.2	1.00	
	1–5	65	9	150.1	1.16	0.6–2.2	726	52	74.8	0.94	0.7–1.3
	6+	91	16	162.9	1.26	0.7–2.1	825	63	76.0	0.96	0.7–1.3
65+	0	504	163	330.0	1.00		1,336	353	249.9	1.00	
	1–5	74	38	503.4	1.53	1.2–2.0	697	189	302.2	1.21	1.0–1.4
	6+	89	36	376.7	1.14	0.8–1.5	669	212	313.1	1.25	1.1–1.4

* Adjusted for effects of age (where applicable), marital status, years of schooling, and quality of housing.

that some of those presumed to have zero or moderate exposure at home were actually subjected to moderate or heavy passive smoke at work or elsewhere outside the home. In this population and during the years of the study, among women aged 25 and over, about 50 per cent were nonworking housewives who would be less likely to be exposed to tobacco smoke outside the home than men, the vast majority of whom were employed. This may in part explain the greater consistency over age groups among women than among men in the increase in relative risk with indicated level of exposure.

All smoking data were obtained in the 1963 census, so no provision can be made for changes in smoking habits which we know took place as a result of publicity about health effects of smoking. Data from a 1975 private census replicating the 1963 census show that the percentage of current cigarette smokers in the 40- to 49-year age range, for example, dropped from 78 per cent to 44 per cent among men and from 50 per cent to 36 per cent among women. On the whole, then, our household passive smoke exposure scores based on 1963 census data will tend to be higher than the actual exposures in later years and to that extent may exaggerate the amount of exposure required to match with a given risk of death from arteriosclerotic heart disease. We also have no data on changes in the household composition which may have occurred prior to or after 1963. Thus, we implicitly assume that any such changes occurred randomly in the population.

We have very little data on other risk factors for arteriosclerotic heart disease in the study population. We have tried to adjust for some: smoking, by restricting the study to nonsmokers; age and sex, by assessing the risk separately for eight age-sex groups; and housing quality, marital status, and years of schooling, by binary variable multiple adjustment. A final check by multiple logistic and Poisson regression adjustment gave virtually identical results. Two other studies encourage us to disregard hypertension and cholesterol as possible confounding factors. The Garland et al. (6, 7) study showed no significant differences in systolic blood pressure, obesity index, and plasma cholesterol between women married to present or ex-smokers and those married to men who never smoked. Similarly, the Svendsen et al. (9) study showed no significant difference in blood pressure and serum cholesterol between men whose wives smoked and those whose wives were nonsmokers. However, other factors such as diet and exercise might differ in families with and without smokers; we cannot ignore the possibility that such differences could influence our findings.

In summary, this 12-year study of a nonsmoking population of white men and women aged 25 and over suggests that nonsmokers who live with smokers are at a higher risk of death from arteriosclerotic heart disease than those who live with nonsmokers. It seems reasonable to suppose that tobacco smoke is a factor in the increased risk.

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